II. Methodology

II.1 Introduction

The methodology used in the current study draws on and extends that developed in our earlier work (Naval Postgraduate School 1997). The main difficulties in estimating the economic benefits derived from naval forward presence and crisis response is in establishing a credible counterfactual argument as well as a meaningful measure of impact. Specifically, what would have been the state of the United States economy if naval forces had not responded to the crisis at hand? Given that naval forces did respond, what is the relevant measure to capture the economic impact associated with this response?

II.2 Conceptual Issues

Both problems are fraught with a number of conceptual issues that need to be resolved before the calculation of economic benefits can be undertaken. First, by their nature, crises tend to have a negative impact on markets and economic activity. Forward-engaged naval forces are often the first to respond to a crisis and their arrival on scene usually has a stabilizing political influence. The stabilizing influence extends to economic activity as well. As noted in the Introduction and based on our first study, oil appears to be the most tractable vehicle for analyzing the economic benefit of naval forward presence and crisis response. Because oil is essential to nearly all-economic activity in the industrialized world, price movements of that commodity in reaction to world events provide a useful index of the overall economic impact of international crises, and of the response of naval forces to them.

Second, it is essential to select an index capable of reflecting the market's interpretation of the severity of a crisis as well as the degree to which trader confidence is restored following the response of naval forces to a crisis. Because oil futures prices provide more information than spot prices, this study uses futures prices to explore the effect of naval forward presence and crisis response. Oil futures markets serve as an efficient substitute for the bulk storage of oil. Instead of stockpiling oil reserves, futures markets such as the New York Mercantile Exchange (NYMEX) allow companies to purchase contracts to buy or sell oil at some future time. These contracts are transacted for individual months in the future. Traders base their offers on the best economic, political, and military information available to them at the time the contract is traded. As a result, futures prices are considered to be the best-unbiased estimate of the likely spot or daily price of oil when the contracted delivery date actually arrives [Bopp 1991].

II.3 The Use of Futures Markets

Futures transactions generate oil price forecasts that reflect traders' confidence that oil will be readily available at some future point in time. Futures prices can thus be used to assess the effects of naval forward presence and crisis response on market confidence in oil availability. Perhaps more importantly for purposes of this study, the use of futures markets allows the effects of naval crisis response on oil markets to be isolated from those caused by other events.

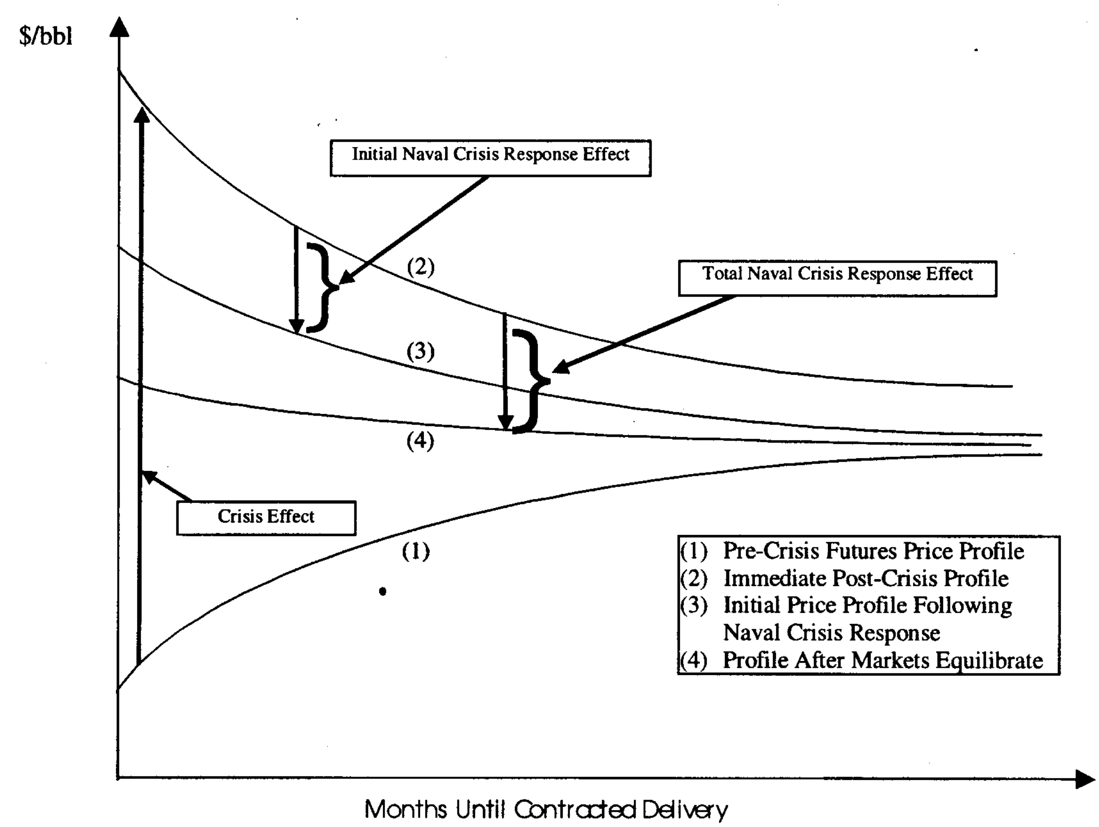
The broad outline of the study methodology is to track futures oil prices, observe the increase in prices caused by a crisis and the reduction and stabilization of the prices when naval forces arrive on scene. This generates an estimate of the value of the crisis response of naval forces in terms of the price paid for oil. Furthermore, when used as an input to econometric models, futures prices can be used to compute the long-term effects on economic activity in the United States and other world economies.

II.3.1 Identification of Market Anticipations

The notional pattern is assumed to be as follows. Prior to a crisis, oil futures market curves generally slope upward as shown in Figure 1, Curve 1. Curve 1 reflects both the cost of storage and the general expectation among traders that oil prices will increase over time. With the advent of a crisis, however, future availability of oil is in doubt and traders attach an uncertainty premium to there ask price [Gabilon 1995]. The effect on futures prices is twofold. First, such a development increases futures prices for all months (indicated by an upward shift in the futures price schedule).

Figure 1

Notional Relationship Between Naval Crisis Response and Oil Futures Markets



Second, the slope of the futures market curve becomes negative (Figure 1, Curve 2), reflecting traders' willingness to pay a premium for immediate possession of oil. When naval forces respond to the crisis, some of the uncertainty concerning oil supplies is alleviated, which shifts the futures price curve downward and decreases the short-run premium paid for immediate possession of oil. These effects are evidenced by a downward shift and flattening of the futures price schedule (Figure 1, Curve 3). Over time, naval forward presence reduces risk to oil supplies and alleviates traders' concerns over oil availability. Increasing confidence in oil supplies can be seen graphically by a further flattening of the futures price curve (Figure 1, Curve 4).

II.3.2 Calculation of Economic Benefits

In the analysis that follows, futures prices are used to compute two different measures of the benefits derived from naval crisis response. First, potential savings in oil import bills alone are estimated by multiplying the differential between the higher prices caused by the crisis and the prices moderated by naval crisis response by the amount of oil imported during the period that begins with the onset of the crisis and ends when markets stabilize. A second, far larger measure is the effect of lower oil prices over time as they spread through the economy affecting production, employment, inflation and more.

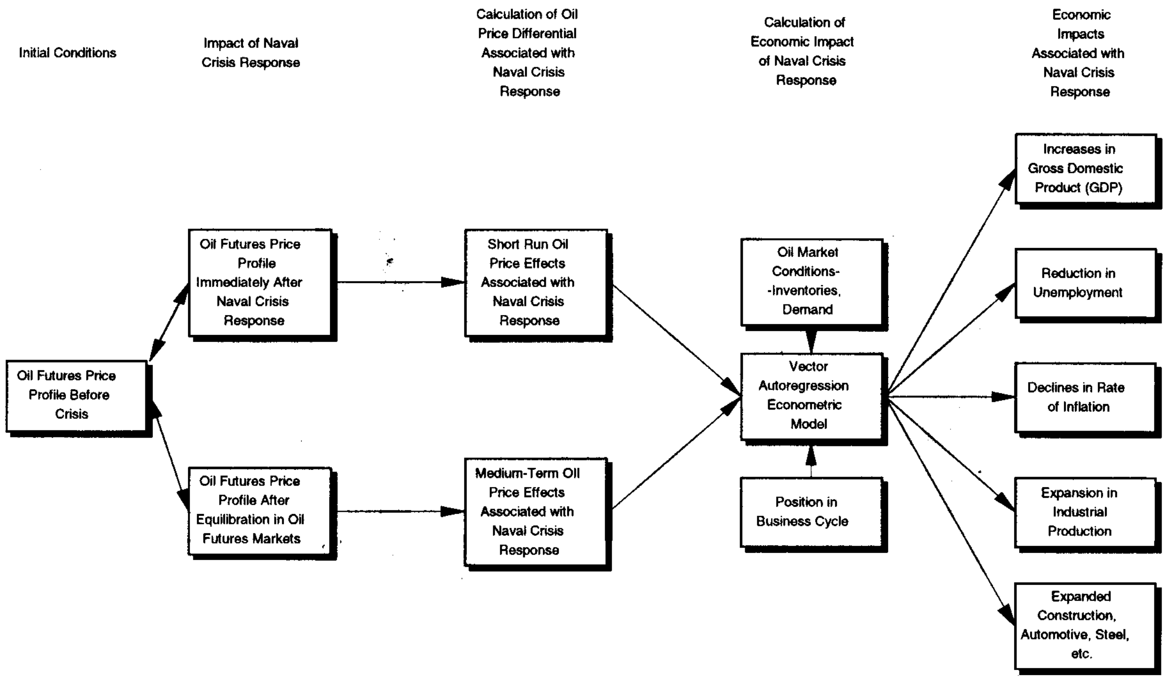
These much larger effects on economic activity in the United States and other world powers are estimated through the application of a class of econometric models originally developed by Christopher Sims of Northwestern University in the early 1980s [Sims 1980]. In Figure 2, the box labeled 'Vector Autoregression Econometric Model' (VAR) refers to a model for the United States economy developed for the current study along the lines of the original Sims' estimation framework. The short-term oil price effects associated with naval crisis response are the difference between curves 2 and 3 in Figure 1, and they become part of the input data for Sims' model to estimate short-term economic benefits. For long-term economic benefits, the difference between curves 2 and 4 in Figure 1 is used instead, since curve 4 represents the futures prices after a new equilibrium has been established.

Summing up, the actual steps used in computing the economic benefits of naval crisis response are outlined in Figure 2. Using the various NYMEX oil future prices from Figure 1 as inputs to the model of the United States economy (VAR), the likely level of GDP and key components under each set of prices is calculated. The differential between the resulting GDP scenarios (based on the sets of prices noted in the previous paragraph) is interpreted as the effect (avoidance of lost income/GDP) brought about by the naval crisis response.

When compared with an examination of oil spot prices, the methodology developed here, which is based on futures prices, better captures the true effects of naval forward presence and crisis response. Relying solely on spot prices may lead to a conclusion that naval forces produce a price effect that is only temporary and of little economic significance. In reality, naval forward presence and crisis response alters key price structures months into the future. Because oil futures prices, as used in this analysis, provide considerably more information about the response of oil markets to naval activity than do spot prices, this methodology captures larger, longer-term economic benefits of naval crisis response. With the methodology in place, it is applied to a specific crisis.

Figure 2

Methodological Overview: Steps in Computing the Economic Benefits Derived from Naval Crisis Response



II. 4 Model Extensions in Current Study

The steps noted above comprised the core of the approach used in our initial study and provide the key building blocks for the current effort. Specifically, the present study extends this approach in several key areas. Using the method outlined above one still has great difficulty in making a convincing argument that changes in oil prices or other key economic variables during a period of crisis were due in large part to the movement of naval forces from forward presence positions. Even though in our earlier cases in the Gulf a clear pattern seemed to exist between crisis response and oil price movement, the strongest arguments making this link had to rely largely on the process of elimination; i.e., no other credible events could have produced the observed pattern of oil prices.

A second problem is that naval forward presence and crisis response analysis has focused almost exclusively on oil markets. Clearly however, other markets concerned with safety of supplies, access to raw materials, future economic conditions and the like must also be affected to one extent or another by the movement of naval forces at critical junctures. To overcome these limitations the current study incorporates several new elements:

II.4.1 Additional Markets

With increased globalization and the increased interlinking of markets, it is clear that naval actions are likely to affect exchange rates, share values, and a whole host of related commodity indexes. Associated movements in these markets are also likely to impact on the US economy. Specifically, associated movements in one or more of these markets may enhance the positive impacts of naval actions or, conversely, offset the oil derived benefits. For example although naval crisis response often lowers oil prices, it may simultaneously weaken the yen, providing Japanese exporters with a competitive edge in the US market. Subsequently, increased imports and associated loss of jobs could conceivably offset all of the benefits derived from lower oil prices.

The current study therefore extends the basic oil model outlined above by incorporating movements of several key foreign exchange rates (the forward values of the yen, mark and pound) into the analysis. Also included are several key commodity futures indexes, the CRB commodity index and the Goldman-Sachs commodity index. Finally, several key share markets, the New York Stock Exchange Composite Index, the S&P100, the FTSE, the Nikkei and the Hang Seng are also included in the analysis.

II.4.2 Event Analysis

The second major extension of our earlier model was to design a method for statistically linking naval actions and other events to price movements in key markets. As noted above, our earlier study made this key connection largely through the process of elimination. Event analysis provides a true statistical test of the association of naval actions and markets. It also can be used for hypothesis testing. Specifically, do naval actions increase market uncertainty or do they provide a stabilizing impact? Do naval actions produce only a transitory movement in market prices or are these actions responsible for longer run adjustments in these markets? If the latter is the case, the credibility of the forward market analysis outlined above is strengthened in that the consequences of naval actions are not confined to the short-run up-and-down fluctuations of spot prices. Instead, these actions actually set in motion a whole series of economic adjustments that, taken as a whole, provide significant economic benefits.

Basically, event analysis consists of coding events (actions, key developments) with a subjective evaluation of their likely consequences. In this study we have used a scale of –3 to +3 to characterize individual actions. For example if events clearly relieve tension and reduce the chance of open conflict in the region, they would be given a score of –3. On the other hand, provocative incidents would receive a +3. If it is unclear what the consequences of an event might have been, several hypothesis can be tested. In short, rather than speculating as to the manner in which markets actually perceived the event, alternative specifications can be tested to determine which scoring system best depicts the manner in which markets reflected the significance attributed by traders to naval and non-naval events.

For example, in the Taiwan Strait case examined below, naval forces account for two important events—December 19, 1995 when the USS Nimitz Battle Group crossed the Taiwan Straits for the first time since 1979 and March 22, 1996 when the USS Nimitz Battle Group again arrived in the vicinity of Taiwan. One school of thought contends that both events heightened tensions in the region, thus elevating oil and other affected market prices. Another school of thought contends that both events, by showing US resolve to defend Taiwan actually defused tensions, thus causing a drop in affected prices. Using both positive and negative signs for these two dates one can statistically test for the interpretation that best fits the facts. For the case at hand, it is clear from the analysis below that the second interpretation is the correct one.

Statistically, several regression-type techniques can be used to conduct an event analysis. The ones chosen here are described at length by Pesaran & Pesaran (1997). The first technique, the Cochrane-Orcutt iterative procedure, is used to compute maximum likelihood estimators under the assumption that the regression disturbances follow an autoregressive (AR) process. This particular procedure is useful because it corrects for serial correlation (correlation of the error terms), thus producing superior estimates to those usually associated with least-squares regression. This technique is used to assess short-run movements that clearly do not have a long-run component. For example several tests are undertaken to determine which events (naval or non-naval) are responsible for the uncertainty in key markets as measured by the spread between the first and second contract (the contract for oil to be delivered next month and the contract for the second month from now). Do naval events create uncertainty thus increasing the spread, or do they provide stability and assurance of supplies thus reducing the spread?

II.4.3 Shock and Long-Term Adjustment Analysis

To test for long-run associations between naval actions and key markets we adapted Pesaran & Pesaran's autoregressive distributed lag (ARDL) approach to cointegration. This technique has been applied (Looney 2000, Looney and Frederiksen 2000) to a wide variety of research problems involving shocks and longer run adjustments. If two variables, say the NYMEX oil price and Brent oil price, establish a long-run pattern with each other they are said to be cointegrated. Short-run shocks can disrupt the pattern. However these shocks simultaneously set off an adjustment process restoring the historical pattern. For example if there was a long-run pattern between the NYMEX and Brent markets, a sudden jump in the Brent price due perhaps from a disaster in the North Sea, prices in the NYMEX market would gradually increase to restore the original longer-run pattern.

In our example, oil prices on any one date can therefore be said to reflect two forces—the long-run adjustment to a normal pattern and a short-run movement in response to an event shocking the system. Technically, any change in price will reflect, to one extent or another, these short and long-run components.

II.4.3.1 The ARDL Approach to Cointegration

The autoregressive distributed lag (ARDL) approach to cointegration is used extensively below for several reasons. First, the procedure establishes a fairly strict and unambiguous set of criteria for selecting the appropriate lag structures. Specifically, the analysis embodies several summary statistics that can be used to determine if the appropriate lag between an event and its impact is one, two or even more days. This useful feature takes a lot of the guesswork out of relying on visual charts to determine the pattern. Second, the technique allows us to go beyond the day-to-day fluctuations in prices to assess the longer-term ripple effects associated with a crisis. Clearly, if an event increases prices one day and in turn prices fall the next, the event may appear to have little consequence in terms of economic costs or benefits. On the other hand if this shock carries over to a series of longer-term adjustments, the event can have considerable costs (or benefits). The ARDL approach was designed to identify the occurrence of this type of phenomenon.

II.4.3.2 An Example

These points can be best illustrated with a typical example from one of the cases. Using the timeline from the Taiwan Strait case, naval and other events over the period from December 1, 1995 to April 2, 1996 are coded on a scale of +3 to –3 (Appendix B) depending on their anticipated impact on NYMEX oil prices. Here, several sets of codes are logical. EVENT3 assumes a favorable response (downward pressure on oil prices) from each of the naval events.

As a basis of comparison and hypothesis testing, the series, EVENT3A, is constructed on the assumption that the initial naval event on December 19 destabilized oil markets (resulting in a price increase that day). However, the March 22, 1966 event involving the Nimitz retained its value of (-3). In constructing the series EVENT3B, both naval events receive a positive score on the hypothesis that markets treated these events as the prelude to increased tension and uncertainty. Finally, in constructing the scores for EVENT3C, all events, naval and non-naval receive a positive score on the assumption that they destabilize oil markets.

To determine which set of assumptions (EVENT3, EVENT3A, EVENT3B or EVENT3C) best depicts the manner in which oil market traders interpreted the events during this period, the ARDL regression formulation noted above was undertaken four times (one for each of the EVENT series). The outcome when EVENT3 set of assumptions was assumed to be the relevant depiction of market sentiment produced an equation of the form:

$$(1)\ \Delta NYMEXS = \underset{(-1.06)}{-89.8\,\Delta INTP} + \underset{(6.29)}{0.7\Delta BRENTS} + \underset{(2.33)}{13.5\,\Delta EVENT3(-1)} - \underset{(-6.37)}{0.6\,ecm(-1)}$$

where NYMEXS is the NYMEX spot rate, BRENTS is the Brent spot rate, EVENT3 is the various naval and non-naval events from the time line, INTP is the intercept term and ecm is the error correction mechanism. Δ is the variable's change from the previous period and (-1) is the variable lagged one period. Terms in parentheses below the equation are the t-ratio (regression coefficient divided by the standard error) for the associated variable. The t-ratio for each variable indicates that all variables except the equation intercept term (ΔINTP) are statistically significant at the 95% level of confidence. The ecm term itself has the form:

$$ecm = NYMEXS + 155.4INTP - 1.1BRENTS - 23.37\ EVENT3$$

The equations are interpreted as follows.

- During this period the NYMEX market formed a long-run pattern with the BRENT market and the EVENT3 term (evidenced by the statistical significance of the ecm term).
- In the short-run, movement in either the BRENT or EVENT3 term set off a shock that disrupted the long-run pattern of the three variables.
- In this example, naval events have a negative sign (assumed to reduce oil prices) in the ecm. It follows that a naval event would lower oil prices in the short-term (given the positive sign on the EVENT3 term).

- Following a shock (that, for instance, raises the price of oil in the short-run), the ecm term (with its negative sign) begins to pull that price downward until its long-run pattern with the other two variables is restored.

- The speed of this adjustment is proportional to the gap between the NYMEX, Brent markets and the EVENT3 term (the negative signs on the Brent and EVENT3 terms in the ecm). The coefficient on the ecm term controls the speed of adjustment with 0.6 being a relatively large term (the term varies from 0 to 1).

- Since naval events have a negative sign in the EVENT3 term and that term in turn has a negative sign in the ecm, naval events increase the size of the ecm term.

- In turn, the ecm has a negative sign in the NYMEXS equation. Naval events therefore are seen as an element that tends to reduce NYMEX prices over time.

Summing up the Taiwan Strait example, the event variables are designed to vary largely based on the weights attached to the two major naval events: the first was on December 19, 1995, when the USS Nimitz Battle Group crossed the Taiwan Straits for the first time since 1979 and the second was on March 22, 1996 when the USS Nimitz Battle Group again arrived in the vicinity of Taiwan. In the EVENT3 variable, both naval events have negative signs (-2 for the first and –3 for the second). Here, the hypothesis is that each would have a stabilizing effect on oil prices, lowering the spot and forward rates. Event variable EVENT3A changes the December 19 naval event to +2 (leaving March 22 at –3), while event variable EVENT3B assigns +2 and +3 to the respective naval events; i.e., naval events would contribute to the increase in oil price. In EVENT3C all of the event variables, naval and non-naval, have a positive sign.

Based on these event codings, the results for the all the event variables are shown in Table 1. Note that the statistical significance of the event variable (as indicated by the t-ratio) declines as we move from the assumption that naval actions stabilize markets to the assumption that naval actions increase uncertainty and destabilize markets. The assumption that all events, naval and non-naval, destabilize oil markets (EVENT3C) has the lowest statistical significance of the four depictions. Given the sample size and degrees of freedom, any t-ration value over 2.0 (absolute value) is significant at the 5% level. These results are consistent with the hypothesis that naval events played a stabilizing, rather than destabilizing, role in oil markets during this particular crisis.

II.5 Conclusions

The methods used to extend our earlier research on the economic effects of naval forward presence should lend increased credibility to that approach. While theoretically correct, our earlier work still relied on several subjective assessments at critical steps. These limitations have been addressed through the inclusion of additional markets and regions, as well as the rigor of event analysis and the econometric assessment of short-run event shocks and longer-run market adjustments.

Table 1

Taiwan Strait Crisis: Impact of Naval Forward Presence and Crisis Response on the NYMEX Spot Oil Price—Summary

ARDL(1) Regression Results
Dependent variable is the NYMEX Oil Spot Rate (NYMEXS)

Regressor	Coefficient	Standard Error	t-ratio[Prob]
EVENT3(-1)	13.5	5.8	2.33[.022]
EVENT3A(-1)	13.2	5.9	2.25[.027]
EVENT3B(-1)	10.5	6.1	1.73[.089]
EVENT3C(-1)	3.4	6.6	0.52[.603]

Estimated Long-run Coefficients using the ARDL Approach
Dependent variable is NYMEXS

Regressor	Coefficient	Standard Error	t-ratio[Prob]
EVENT3(-1)	23.4	10.5	2.22[.029]
EVENT3A(-1)	22.8	10.5	2.16[.034]
EVENT3B(-1)	18.3	11.0	1.67[.100]
EVENT3C(-1)	6.1	11.7	0.52[.605]

Error Correction Representation for the Selected ARDL Model
Dependent variable is ΔNYMEXS

Regressor	Coefficient	Standard Error	t-ratio[Prob]
ΔEVENT3(-1)	13.5	5.8	2.33[.022]
ΔEVENT3A(-1)	13.2	5.9	2.25[.027]
ΔEVENT3B(-1)	10.5	6.1	1.73[.089]
ΔEVENT3C(-1)	3.5	6.6	0.52[.603]

Notes: Autoregressive Distributed Lag Estimates ARDL(1) with Δ = change from previous period; (-1) lagged one period; Coefficient = unstandardized regression coefficient. The results are presented in three representations; (1) the standard regression presentation; (2) the long-run coefficients; and (3) the error correction format.